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## GEISSLER TUBES AND COMETS.

FRESH interest is from time to time being awakened in those erratic celestial visitants of our system, about which there is so much that is still enigmatical. The general appearances they present are familiarly known. Their enormous volume is apparent; but not less demonstrable is the extreme tenuity of the vapours or gases composing them; through which, in thick mass, small stars shine with almost undiminished brightness, and traversing rays of light suffer no perceptible refraction. It is further known that the sun has a powerful influence on this cometary matter; for the comets tend to a more condensed and globular form when at a distance from him; but on coming nearer, the substance increases in lightness and volume, and alters in form, giving the phenomena of the *tail*, which is most extended at the perihelion, and, generally turned away from the sun, appears subject to a repulsive force exerted by him.

The question as to the nature of this force has not yet received a decisive answer from physicists, but there is strong probability that it is of electrical nature. This was the opinion of Olbers, and M. Faye's observation that the force diminishes with the square of the distance, and that it is proportional to the active surfaces, is in accordance with the hypothesis. M. Zöllner's theory of electric repulsion between the sun and comets is based on the statical repulsion of two electricities of the same name. But there is an evident difficulty here, in the fact of the distance between two celestial bodies, like the sun and a comet, being too great for polar action to be possible; the action of the two electricities should neutralise each other.

The subject appears to have important new light cast upon it from a series of researches by two Austrian observers, MM. Reitlinger and Urbanitzky, described recently to the Vienna Academy. If a finger or any conductor be brought near the luminous column in a Geissler tube, an attraction is observed, which has been explained by the known laws of electrical influence. But these observers, experimenting with a number of tubes, found some which gave a pronounced repulsion instead of an attraction. These exceptional tubes contained, one bromine, the other perchloride of tin. Besides repulsion, the tubes showed a peculiar green light on the side towards which the column was forced; a kind of electric phosphorescence.

Examined spectroscopically, both tubes gave like spectra, and the most visible parts presented the three bands which are generally attributed to the spectrum of carbon, and which are met with in cometary spectra. This identity of spectra is accounted for by supposing that the light was not furnished by the gases that had been introduced, which may have been absorbed by the electrodes, or precipitated on the glass; but by a trace of some rarefied gas of another kind.

The authors then prepared a number of tubes with various gases (air, oxygen, hydrogen, nitrogen, carbonic acid, and coal gas), exhausting to 2 to 8mm.; and in all these cases they found attraction. But on pursuing the rarefaction further, the effect was reversed; they obtained repulsion. This became more and more pronounced, so long as the nebulous light was not replaced by a singular and stable sort of stratification, which appeared unfavourable to the effect. The light of the negative rheophore shows neither attraction nor repulsion. The rarefaction was continued down to 0·2mm.

When one pole of the induction coil is connected to one of the electrodes of a Geissler tube, and the other pole connected to earth, the interior of the tube may be rendered luminous; (a Smee battery of eight elements was used). In this case there is marked attraction in gas having a tension of 6 to 8mm. Continuing the rarefaction, you come to a neutral point; thereafter the same gases give a repulsion quite as pronounced as the previous attraction; and it may even be observed at a distance of three to six centimetres. This repulsion always increased with the rarefaction, and it was the greatest possible with the greatest degree of rarefaction, viz., 0·2mm.

There is another and still more striking form in which the phenomenon can be studied. A wider tube is employed, somewhat like the electric egg. The nebulous light produced has a remarkable resemblance to the tail of a comet. The authors thought they could even distinguish in it the two principal forms which are presented in drawings of comets, according as the pole employed was positive or negative. The repulsion produced by the finger was here very strong, and manifest at a great distance. When an insulating substance (*e.g.*, an ebonite plate) was brought towards the light, instead of a conductor, there was no repulsion; which proves that the phenomena in question were truly electrical.

Whether or not the theory of cometary repulsion thus propounded be the true one, the apparent

similarity of conditions and phenomena in the two cases is certainly remarkable, and the discovery of this new form of repulsion is one of considerable interest. We may note, in conclusion, that to account for those celestial repulsions M. Faye has endeavoured to prove experimentally a repulsive force exercised by incandescent surfaces. M.M. Reitlinger and Urbanitzky are of opinion (also based on experiment) that the conducting nature of the bodies employed by M. Faye was more important, for the success of his experiments, than the incandescence.

## THE DEVELOPMENT OF STATIC ELECTRICITY.

THE sources whence static electricity may be obtained are various. The best and longest known is friction. Besides ordinary friction, a number of other sources have been found, which are closely allied to it. Thus, in 1732, Gray observed that electricity was developed, when he poured fused sulphur out of a vessel. Again, Nicholson obtained electricity in the clearage of minerals, and Wilson in cutting other substances, *e.g.*, wood with a knife. To this class of sources, lastly, belongs that described by Dessaignes, who found that a glass rod dipped in mercury comes out positively electrified.

A second source, quite different from these, was observed by Volta in the vaporisation of certain liquids. A third is presented in the contact of certain bodies even where there is neither friction nor chemical action between these. Certain chemical combinations, especially combustions, are attended by a development of electricity. Finally, it has been found by M. Becquerel that pressure is a source of electricity, and he has also investigated the electricity which accompanies capillary phenomena.

May a unity be detected in this variety? Is it possible to reduce all these phenomena to one and the same cause? This has recently been attempted by M. Spring, in an interesting paper communicated to the Belgian Academy. The general proposition he enunciates is this:—Every variation in the energy of attraction-force is accompanied by a change in the electrical state of a body. Discussing at some length the different modes of producing static electricity, he endeavours to show that they all involve a change of the attraction-force; and he also illustrates his principle by special experiments, to some of which we here invite brief attention.

M. Spring sets himself the task of proving that when by mechanical means a change is effected in the energy of attraction-force of body, the latter becomes electrical; and further, that when electricity arises, an adhesion or attraction is terminated.

For measurement of the very small quantities of electricity here in question, the author used a delicate arrangement which we have formerly described (see page 266). The point on the scale to which the end of the glass pipe was pulled down indicated the strength of the electric attraction.

A very simple means of altering mechanically the attraction of the minute particles of a body is afforded in the stretching of a caoutchouc plate. The inter-molecular spaces are enlarged, and as the attraction is a function of the distance of the molecules from each other, changes must here occur in the energy of the attraction. Such a change of state is otherwise indicated by the variation of temperature where a stretched caoutchouc plate returns to its ordinary state, or conversely.

Now, it appears from experiment that a change in the state of mechanical tension of the caoutchouc essentially alters its electrical state. Thus, if we take a plate of vulcanised caoutchouc, from which the superfluous sulphur has so far been removed that it has nearly half the transparency of fine caoutchouc, stretch it strongly, and rub it lightly with a piece of cloth, it takes a quantity of electricity so considerable as no longer to be capable of being measured with the electric dynamometer. The adhesion of the pith-ball cannot be terminated by a pull of 15mgr. If now the tension of the plate be relaxed, the quantity of electricity diminishes; and when the plate has come back to its natural state, all trace of electricity has disappeared. *The termination of the stretched state of the caoutchouc thus results in the consumption of a certain quantity of electricity.* If the electrification of the stretched plate at the beginning be very strong, if it represents the maximum of electricity the plate can assume, then a small quantity still remains after the plate is relaxed. Measured by the dynamometer, this nowhere exceeded 2mgr. "We must, however, infer," says the author, "that the quantity of electricity consumed when the plate returns to its ordinary condition is intimately connected with the change of attraction which occurs in these alterations of state.

"This first experiment is already decisive. Indeed, if the change of tension of the caoutchouc were without influence on the quantity of electricity, this would be greater in the apparatus, when the caoutchouc is in the natural state, for then it would be spread over a less surface; this will readily appear if it be considered that the surface of caoutchouc which I used became nearly sevenfold smaller, when the state of tension ceased. The electricity which originally was spread over a surface of a certain extent was now spread over seven times less surface, so that its density must have been increased sevenfold. We must therefore conclude that the relaxing consumed electricity.

"Conversely, if we take an unstretched plate of caoutchouc, which is perfectly neutral, and stretch it to the maximum, we find it charged with a very small quantity of electricity. This quantity measured with the dynamometer was always less than 1mgr. . . . .

"I have repeatedly tried to determine the sign of the electricity which is developed by the stretching of caoutchouc, but always failed, as the quantity is too small to afford an exact determination of its nature. If we assume (and

there is some probability) that it is positive electricity, the question arises, whither goes the negative electricity, which, at least, according to commonly received ideas, must be simultaneously developed. This question remains unanswered."

Another means of altering the attraction-force in bodies is furnished in the solution of solid bodies in liquids, when no chemical processes occur therewith. MM. Becquerel and Wüllner have demonstrated the production of electrical currents in dissolution of salts in water. According to M. Spring's principle, static electricity must also be developed in such cases, and he succeeded in proving this.

He employed, in these experiments, chloride of sodium, sulphate of copper, and nitrate of potash. A small cylinder of each salt was cut; on one of the circular ends was placed a platinum plate; the curved surface was coated with shellac, and the other free end surface was brought into contact with water. The water was connected to earth, and while the salt was dissolving, free electricity could be detected on the platinum plate by means of the dynamometer. Chloride of sodium gave the least quantity of electricity; sulphate of copper gave more, and here it increased with the temperature of the water, partly because the solubility increases with the temperature, but partly also because the temperature of itself acts on the electrification of the salt; and this action was also demonstrable when instead of water mercury was used for the experiment. Nitrate of potash gave still better results: the quantity of the electricity was greater, and the action of rise of temperature more decided. These facts, then, demonstrate (in the author's opinion) that the phenomenon of solution is accompanied by production of a certain quantity of electricity, which increases with the rapidity of the solution.

We may now shortly notice some of the evidence M. Spring adduces to prove that all the hitherto known sources of static electricity are reducible to the principle which he has enunciated.

When two bodies in contact with each other are separated, the electricity which appears is greater, the more the two bodies have adhered to each other. This M. Spring proves by experiments, in which he brings a glass plate into contact with mercury, measures the adhesion, and then compares it with the quantity of electricity developed on separating the plate. By changing the temperature the adhesion of the plate was varied, and the quantity of electricity developed on the glass by pulling away was always, and in the same direction, different. A similar result was obtained when he altered the surface of the mercury by blowing on it or strewing it with lycopodium. In the former case, the adhesion and the electricity were smaller; in the latter, they were both nil.

The observation of Gray, that electricity appears when fused sulphur is poured out of a vessel, was repeated by M. Spring with an hour-glass, in which he melted various easily liquefiable alloys and metals, which in the liquid state showed different adhesion to the glass, while the adhesion could be entirely destroyed by strewing the glass with lycopodium. In all cases the electricity produced by the outflow in the glass was greater, the stronger the adhesion of the substance to the glass.

It may be concluded, then, the author believes, that electricity arises from every termination of attraction, or at least that it accompanies this. According to the principle of reciprocity, he adds, we must suppose that electricity, of itself, in certain circumstances, can diminish or terminate attraction.

## RUSSIAN TELEGRAPHS IN 1874.

THE Official Report on the condition of the telegraph system in Russia has been recently published.

*State Telegraphs.* We learn from it that Russia possessed of State telegraphs at 1st January, 1875, lines to the extent of 57,718¾ werst, with a total wire length of 111,813¼ werst (the werst = about three-quarters of an English mile). The increase in 1874 was 1,121¾w. line-length, and 4,531¼ wire-length. The number of stations added in 1874 was 34, making a total at 1st January, 1875, of 701 stations. To the previous apparatus were added in 1874, 49 Morse apparatus, and 22 Hughes, with 2,705 Meidinger elements, so that on 1st January, 1875, there were altogether in action, 1,650 Morse, and 98 Hughes, with 54,291 Meidinger elements.

*Private Telegraphs.* At the beginning of 1875 the extent of railway telegraph lines was 14,982w., wires 33,064w., and the number of stations 901 (showing an increase of 2,009w. in the lines, 3,994¾w. in the wires, and 108 in the stations). The Anglo-Indian telegraph line had, as before, an extent of 3,407w. line, 70,834 wire, and 53 stations. There were constructed in 1874, of telegraphs belonging to private companies and persons, 18¼w. line, 18¼w. wire, and 7 stations, making a total, at beginning of 1875, of 342¼w. line, 342¼w. wire, and 36 stations.

Thus the entire telegraph system of Russia contained, at beginning of 1875, 76,450¼w. line, 152,303¼w. wire, and 1,691 stations (showing an increase of 4,101¼w., 9,233¾w., and 135 in the three cases respectively.

At the beginning of 1875 there were 126 post-offices open for despatch of telegrams.

*Personnel.* At the 1st of January, 1875, the entire number of persons employed was 6,393 (showing an increase of 380 persons during the year). Of these there were engaged in the telegraph-administration 150; at stations, 6,243, of whom 576 were station-superintendents (+ 23), 2,923 male operators (+ 271), 520 female operators (+ 24), 55 students (same number), 574 overseers (+ 7), and 1,483 messengers and servants (+ 74). The proportion engaged in the administration is 2·3 per cent.; in oversight of lines 10·8 per cent.; in sending and receiving telegrams 63·7 per cent.; in despatching of telegrams to the proper addresses, and service, 23·2 per cent.

*Telegraph Correspondence.* The total inland correspondence (of paid and free telegrams) was in 1874, 3,116,168, showing an increase of 10½ per cent. on 1873. The total international traffic (telegrams despatched and received) was 684,257,

showing an increase of 11½ per cent. on 1873. The entire number of telegrams was thus 3,800,425; (inland correspondence, 76·8 per cent., international, 17·7 per cent.; sent free, 5·5 per cent.)

Of the international correspondence, most telegrams were sent to and received from Germany, 206,137 (showing an increase of 18,046). Next come in succession, England, 117;114 (+ 17,655); Austria-Hungary, 74,953 (— 10,282); France, 61,246 (+ 8,478); Sweden, 29,366; Italy, 22,316; Holland, 22,283; Belgium, 15,949, &c. With countries beyond Europe, 3,289 telegrams passed between Russia and Asiatic Turkey; Persia, 3,002; America, 819; Egypt, 575; China, 379, &c.; Australia, 1. There was 10·9 per cent. increase in the foreign telegrams. The correspondence with Germany was 33·6 per cent. of the whole, with Great Britain, 19·1 per cent.; and with France, 9·9 per cent. The traffic with these three countries had increased 13 per cent. With America the increase is 117·2 per cent., with Spain, 54·8 per cent.; with Denmark, 32·3 per cent., &c. The correspondence with Egypt had diminished 34 per cent.; with Austro-Hungary 12 per cent.; with Roumania, 4·3 per cent.; with Persia, 1·05 per cent.

Of transito-telegraph correspondence, there were, in 1874, 58,493 telegrams (28½ per cent. more than in 1873). This class of correspondence is forwarded in two ways; the correspondence of Western Europe and America with Persia, India, and Australia, over Warscha, Kertsch, to Djalfa; and that with China and Japan, over Siberia to Wladiwostock. By the former were sent 47,022 telegrams; by the latter 11,471 telegrams. Of this correspondence Great Britain contributed 83·5 per cent.; Germany, 6·5; America, 4·0; France, 2·6; and the remaining States, 3·4.

As regards traffic of the separate stations, it appears that in 1874 there were thirty stations at which the number of telegrams handed in amounted to 15,000, and of these stations, thirteen with more than 30,000. We give a few of the larger numbers:—St. Petersburg, 449,680; Moscow, 289,748; Odessa, 107,697; Warschau, 80,297; Kijeu, 61,131. The entire number of telegrams handed in at the thirty stations referred to was 1,677,293; and the total of telegrams exchanged 6,498,329. At the remaining stations, 1,548,315 and 6,025,327. The thirty stations, accordingly, present more than half of the whole telegraph activity of Russia. At twenty-six of these thirty stations the traffic had increased, and at four diminished.

On an average, each of the above-mentioned apparatuses gave 7,140 telegrams as against 6,223 in 1873, an increase of 917 telegrams for each apparatus.

Of inland telegrams, most were sent in May (viz., 277,228) fewest in February (236,735). Of foreign telegrams, most were exchanged in July (31,123), fewest in January (21,030).

*Revenue and Expenditure.* The gross receipts of the Telegraph Department in 1874 were 4,822,661 roubles, against 4,630,029 roubles in the previous year, an increase of 4·1 per cent. (The rouble = about 3s. 4d.) The expenditure was 3,899,748 roubles, against 3,646,220 in 1873, an increase of 6·9 per cent. The net revenue during 1874 was 922,913 roubles against 983,809 roubles in 1873, or about 60,896 roubles less. If the gross receipts be divided among the telegrams forwarded, we have an average receipt for each telegram of 1 rouble 48kop. In each werst of wire-length the receipts amounted to 42 roubles 58kop., the expenditure to 34 roubles 93kop., the net receipts 7 roubles 63kop. (Readers who may wish further details of this instructive report are referred to the *Russische Revue*, 5 Jahrgang, 10 Heft.)

## ON A NEW DYNAMO-MAGNETIC PHENOMENON.

BY MM. TREVE AND DURASSIER.

LET a horse-shoe magnet, of any length, be covered on one face with a varnish, or better, a plate of glass. If on the neutral part we place a cylinder of soft iron, we shall see this move towards the poles, which it will reach in a time which is, naturally, a function of the weight of the cylinder, and the coercitive force of the magnet. The magnetic attraction, then, is here exerted not merely in the limited field which has been assigned to it; but over the whole extent of the magnet.

Thus we have a new way of estimating the magnetic force by the *mechanical* work it does. The product of the weight of the moveable body by the space passed through, divided by the time, will be the exact measure of this magnetic force. If we determine this force, *e.g.*, for three large and three small magnets, similar in form and weight, and containing respectively 0·250, 0·500, and 1 per cent. of carbon, we can see how it may perhaps be possible to determine the unit of magnetic force, the "*magnetie*," and to fix its equivalence in kilogrammetres.

We have made great efforts to determine the magnetic conductivity of steels in relation to their proportion of carbon; but the want of a *rigorous mode* of estimation of magnetic forces has always stopped us. The phenomenon described will fill the gap, and help us to reach the desired end. We will, however, indicate here the plan we have followed.

If we take, *e.g.*, a steel $A_1$, with 1 per cent. of carbon, of our first Creusot series, its coercitive force is found approximately 47 degrees with the compass. We now enclose it in coils, like an ordinary electro-magnet, giving the coils the proportions of length, section, wire, &c., established by M. du Moncel for obtaining maximum magnetic force; and pass a very strong current. The magnet no longer gives 47° but 64°. If 47 and 64 were absolute numbers, we might say that the magnet $A_1$ has 47 of permanent magnetism, but can take 64 in the temporary state. 64 would represent the *magnetic capacity* of the magnet with 1 per cent., that is, the *maximum of magnetism* it can receive. The difference between 64 and 47 would give the magnetic conductivity.

Take now $E_1$, the extreme steel of the series, with 0·250 per cent. of carbon. Its coercitive force is 13. If we adapt to it the same coils as to $A_1$, since they are identical in form and weight,

we get 69 for the magnetic capacity. The difference between 69 and 13 will be the magnetic conductivity of steel with 0·250 per cent. of carbon.

We have operated in the same way with $B_1$, $C_1$, and $D_1$, and have obtained the following table:—

| | Coercitive force. | Magnetic capacity |
|---|---|---|
| $A_1$ | 47 | 64 |
| $B_1$ | 45 | 66 |
| $C_1$ | 42·5 | 67 |
| $D_1$ | 33·5 | 68 |
| $E_1$ | 13 | 69 |

The magnetic capacity of a soft piece of iron, the same in form and weight, was 71. These *approximate* relations show the importance of finding a mode of rigorous measurement of the magnetic force.—*Comptes Rendus.*

## COMPARISON OF THE BATTERIES USED IN TELEGRAPHY.

REPORT OF M. GAUGAIN UPON THE VARIOUS TYPES OF DANIELL, CALLAUD, MARIÉ-DAVY, AND LECLANCHÉ BATTERY.

In order to ascertain the value of the various battery couples which I had to examine, I measured the electromotive force and the resistance of each of them under some of the conditions in which it may be placed. I must, first of all, describe the experimental methods I have employed in order to determine these two points, the electromotive force and the resistance.

*Measurement of the electromotive force.*

I employed in the experiments I am about to describe the *method of opposition* which I have already made use of in my former experiments upon electromotive force, and I took for a unit of force the electromotive force of a thermo-electric couple one of whose points of junction is kept at zero and the other at a temperature of 100°. For the purpose of expressing this unit I employ the symbol $\frac{Bi - Cu}{0 - 100}$.

I long ago (*Comptes Rendus, 29th March*, 1854) called attention to the fact that the electromotive force of bismuth-copper thermo-electric couples varies from one couple to another, in spite of all the care that may be brought to bear on the construction of the battery; and although this statement has been called in question, I see no reason to modify anything I have said upon this subject in the *Annales de Chimie et de Physique* (1862, 3rd series, vol. lxv., pp. 27-34). The electromotive force which I have taken as a unit is not, then, the electromotive force of any particular bismuth-copper thermo-electric couple, but is the mean electromotive force of the couples forming the battery of which I made use.

As this battery was composed of only forty couples, it would have been quite inadequate to measure the electromotive force of the other batteries I examined, and I therefore employed, as auxiliary batteries, three different hydro-electric batteries, a cadmium-iron battery, a zinc-cadmium battery, and a Daniell battery: my standard battery comprised in all forty thermo-electric couples (bismuth-copper), three hydro-electric couples (cadmium-iron), three couples (zinc-cadmium), and one Daniell couple.

The couples of my thermo-electric battery have been described and illustrated in the *Annales de Chimie et de Physique* (May, 1862): they are made with horse-shoe bars of bismuth, only three millimetres in diameter. The cold junctions were immersed in a bath of rain water at the temperature of the air, and the warm junctions were placed in a bath of paraffine heated by a hot water bath (*bain-marie*). Paraffine insulates better than any other substance which I had previously used, and it has the advantage of giving off no smell at a temperature of 100°.

The hydro-electric battery (*Cd — Fe*) I used is arranged like a Daniell battery: the negative electrode is a plate of cadmium which is placed in a porous cell containing a solution of sulphate of cadmium. The positive electrode is a thick iron wire, and is placed in the outer cell, which contains a solution of sulphate of iron. The chemical action which takes place in this battery is of a more complicated nature than that which goes on in a Daniell battery, and I confess that I have not endeavoured to exactly analyse it; I have limited myself to ascertain a fact which is the only one of importance to me, namely, that the couple (*Cd — Fe*) preserves the same electromotive force during a rather long period when out of action.

When a couple is intended merely as a standard by which to measure the electromotive force of other couples, it is a matter of little importance whether or not it is liable to become polarised under the influence of the current. As the couples which serve as a standard are opposed to the other couples, which it is desired to measure, only during a fraction of a second, and as the current which passes during this short space of time is extremely weak, it is unnecessary to take the polarisation into account. In order that a couple may serve as a standard, it is enough for it to retain the same electromotive force during a certain time when it is out of action, and this condition is fulfilled by the (*Cd — Fe*) couple, although its electromotive force falls to almost nothing when the two poles have been connected together for a few minutes by a wire of small resistance. The force of the couple (*Cd — Fe*) is never more than $\frac{Bi - Cu}{0 - 100}$ when the iron is immersed, as I have so far assumed, in a pure solution of proto-sulphate of iron; but the force can be more or less increased by adding to the solution of sulphate of iron extremely small quantities of nitric acid, and the (*Cd — Fe*) couples which I used were graduated by this method in such a way, that their electromotive force differed very little from 20 $\frac{Bi - Cu}{0 - 100}$. Besides the fact that couples giving this amount of force are more convenient to use than weaker ones, I have found that they are also more *constant*, in the sense in which I have here used that term. I have ascertained that the (*Cd — Fe*) couples of my

standard would remain fitted up for seven or eight days together without their electromotive force falling more than one unit. I know of no hydro-electric couple whose electromotive force would vary less in the same time. The zinc-cadmium battery has been already employed by M. J. Regnault in the measurement of electromotive force: it is composed of a plate of zinc immersed in a solution of sulphate of zinc, and a plate of cadmium similarly immersed in a solution of cadmium; the two liquids are separated as in the ordinary Daniell battery by a porous partition. This battery is *constant* in the ordinary sense of the word, that is to say, it polarises to but a very small extent when in action, and even when the interposed resistance is practically *nil;* when, however, it remains out of action, the porous partition does not entirely prevent the mixing of the liquids, the zinc electrode becomes covered with deposits of cadmium, and the electromotive force of the couple diminishes rather rapidly: to reduce this inconvenience, I have made the outer vessel which contains the zinc electrode of a diameter equal to five or six times that of the porous vase in which the cadmium electrode is placed; but even with this arrangement, I have found that the $(Zn - Cd)$ couples cannot remain fitted up during twenty-four hours without their electromotive force falling to the extent of several units. I have, in consequence, adopted the expedient of separating the two liquids of the couples during the intervals between experiments.

Even at the moment when they are fitted up, the $(Zn - Cd)$ couples have not always exactly the same electromotive force, at least when the metals of commerce are employed, as they have been in my experiments, to form the electrodes; these metals are never chemically pure, and the slight differences which exist in their composition suffice to cause the electromotive force to vary slightly. The mean value of the electromotive force of the couples which I have used has been

$$\text{about } 62 \frac{Bi - Cu}{0 - 100}.$$

The remarks made in the case of the $(Zn - Cd)$ battery also apply in the case of the Daniell: the latter polarises very little, even when traversed by a strong current; but as the porous diaphragm does not entirely prevent the mingling of the liquids, the zinc plate becomes coated with a deposit of copper when the couple has been fitted up for a certain length of time. It is remarkable that these deposits of copper do not, in most cases, cause a very notable diminution in the electromotive force of the couple; they are much less injurious than the deposits of cadmium which are formed upon the zinc plate in the case of the $(Zn - Cd)$ couple; it is, however, better to avoid them, and for this purpose I have taken the same precautions, as in the case of the $(Zn - Cd)$ battery; I give the glass vessel destined for the solution of zinc a diameter much greater than that of the porous pot in which is to be placed the solution of copper, and I keep the two liquids separate during the intervals between the experiments.

I employed as electrodes plates of zinc and copper made from metal of commerce, and the zinc plates were not amalgamated; the salts used were pure and dissolved in distilled water. The mean value of the electromotive force of the couples used in the course of my investigations

$$\text{was about } 197 \frac{Bi - Cu}{0 - 100}.$$

As will be seen from what has already been stated, none of the hydro-electric batteries which I have used give an unvarying electromotive force; I was therefore obliged to test, very frequently, the amount of the electromotive force of each of the couples forming part of the standard which I used.

The following is the process adopted in making these tests: I measure first the electromotive force of each of $(Cd - Fe)$ couples by means of the thermo-electric $(Bi - Cu)$ battery; then, by means of three $(Cd - Fe)$ couples, and the thermo-electric battery, I measure the force of each of the three $(Zn - Cd)$ couples; and, finally, I employ the three $(Zn - Cd)$ couples and the thermo-electric battery to determine the electromotive force of the Daniell couple.

This graduation of the hydro-electric batteries, which must be repeated each day when one desires to experiment with a certain exactness, is a long and delicate operation which might be avoided by the provision of a thermo-electric battery, of sufficient power to measure directly the electro-motive force of all the known forms of battery.

But if, with this object, it is desired to use the $(Bi - Cu)$ thermo-electric battery, about 400 couples must be provided; not only would these 400 couples be very costly, but they would occupy a space of from 6 to 7 metres, if the elements were made of the dimensions of those usually constructed by M. Ruhmkorff. A battery of 400 couples would also necessitate the employment of a number of baths the management of which would be extremely difficult. I have thought that the $(Bi - Cu)$ battery might with advantage be replaced by the $(Cu - Fe)$ battery.

This last mentioned couple is six or seven times weaker than the $(Bi - Cu)$ one, and it would consequently be necessary to have 2,500 to 3,000 of the former as an equivalent for 400 of the latter; but, as iron and copper can be used in the form of fine wires, 3,000 $(Cu - Fe)$ couples would take up much less space than 400 of $(Bi - Cu)$. I have had a battery of 100 $(Cu - Fe)$ elements made by M. Ruhmkorff, which is equal to 153 $(Bi - Cu)$ elements, and has only a thickness of 10 millimetres. 3,000 couples arranged in this way would form a battery whose length would not exceed 50 centimetres, and which would only require two baths, one for the cold junctions, the other for the hot ones.

The electro-motive force of the $(Cu - Fe)$ thermo-electric couples varies, from one couple to another, as in the case of those of $(Bi - Cu)$; but a group of 100 elements chosen at random can be taken as a standard, and all the other groups of the battery made equal to it, by adding or taking away one or two elements, as may be necessary.

In order that the junctions of each couple may quickly assume the temperature of the baths in

which they are immersed, it is necessary that these junctions should be bare, and that they should project beyond the mass of the insulating coverings which serve to bind the couples together. I have succeeded after several trials in effecting this arrangement in a satisfactory manner; it appears, however, that it is rather difficult to construct a group of 100 elements arranged like that supplied to me by M. Ruhmkorff, so that a battery of 3,000 elements would still be very costly, notwithstanding the small intrinsic value of the metals composing it. For this reason I have abandoned the idea of having such a battery constructed.

*(To be continued.)*

## ON THE POINTS OF CONTACT OF MAGNETISM AND LIGHT.

(Concluded from page 302.)

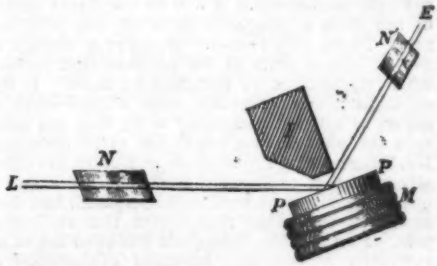
IN the last number of the TELEGRAPHIC JOURNAL we gave a brief outline of Faraday's famous discovery of the rotation of the plane of polarisation of light, transmitted by heavy glass, under the influence of powerful magnetic force. We also pointed out the physical explanation of this phenomenon, and lastly gave a brief description of some recent experiments of Prof. G. Forbes, which, though incomplete, tend to establish a rotation of the glass, when suspended parallel to the lines of magnetic force.

In connection with Faraday's discovery, Verdet, and lately Becquerel, have made elaborate researches on the laws that relate to the phenomena of the magnetic rotation of a polarised ray. Verdet has shown that the magnetic rotations of the planes of polarisation of the rays of different colours follow approximately the law of the inverse square of the wave-length, and that the product of the rotation by the square of the wave-length increases from the least to the most refrangible end of the spectrum; the substances for which this increase is most sensible are those having the highest dispersive power.

A summary of M. Becquerel's researches has recently been given in these columns (TELEGRAPHIC JOURNAL, p. 213 and p. 275). The conclusions arrived at confirm those of Verdet, and further show that when a luminous ray of given wave-length is taken, the rotation by a diamagnetic substance in a magnetic field is proportional to the function $n^2(n^2-1)$ of the index of refraction, and to a factor connected with the diamagnetic power of the body. For bodies of the same chemical family, or of the same chemical radical, the quotient of the magnetic rotation by the function $n^2(n^2-1)$ of the corresponding index of refraction is a number which varies very little.

We now come to the most recent and most remarkable of the later additions to our knowledge of the relationship between magnetism and light. At the last British Association meeting, the Rev. Dr. Ker, of Glasgow, contributed a paper on the rotation of the plane of polarisation by *reflection* from a polished magnetic pole. Dr. Ker had previously distinguished himself by his beautiful and exquisitely-delicate discovery of the effect of the electrification of dielectrics on the transmission of polarised light. This second discovery of Dr. Ker's is still more remarkable, and will ever be remembered as one of the most prominent features of the Glasgow meeting of the British Association.

The accompanying diagram shows the experimental arrangement adopted by Dr. Ker. A beam of light L, polarised by a Nicol's prism, N, falls on the polished surface of an electro-magnetic pole P P, is regularly reflected therefrom, analysed by a second Nicol N′, and enters the observer's eye at E. The magnetic force is




concentrated intensely upon the iron mirror by means of a wedge-shaped mass of soft iron I, which is separated from the mirror by a narrow chink. The angle of incidence varies from 60° to 80°. The plane of polarisation of the incident light coincides with the plane of incidence, (by this means elliptic polarisation is avoided, and initially the two Nicols are exactly crossed, so that the light is extinguished by the analyser.

When the mirror is intensely magnetised either as an N. or S. pole, the light is restored from pure extinction, and disappears again at once when the circuit of the magnetising current is broken. In the next experiment the first Nicol is turned from its initial position through an extremely small angle (*a*) to the right, (*b*) to the left, so that in each case the light is restored faintly from extinction. When the mirror becomes an intense S. pole (*i.e.*, a south-seeking pole), the light is increased by rotation (*a*), but weakened by rotation (*b*). On the contrary, when the mirror becomes an intense N. pole, the effects are reversed. In other experiments the effect of these small rotations (*a* and *b*) and of the magnetisations of the mirror are compensated separately. The compensator is a fine slip of plate glass held at an angle of 45° to the plane of polarisation, between the mirror and second Nicol, and strained by the hand. By this means the optical effects either of the partial rotation of the Nicol or of the magnetisation of the pole can be neutralised down to pure extinction of the ray by the simple compression or tension of the glass-slip. Perpendicular incidence of the ray was afterwards tried, but no good effects obtained, the arrangements being very imperfect.*

* It is extremely important on theoretical grounds to make satisfactory experiments at a perpendicular incidence. Some tentative experiments on this point are in progress in the Physical Laboratory here, by Mr. Stoney and Mr. Fitzgerald, but they await the fuller publication of Dr. Ker's paper.

From these experiments it is clear that when plane-polarised light is reflected from a pole of an iron magnet, the plane of polarisation is turned in the act of reflection, by the S. pole to the right, by the N. pole to the left. The magnetising current, in fact, carries the plane of polarisation with it.

We are indebted to Dr. Ker for the foregoing abstract of his paper, which we understand will shortly be published in full. It only remains for us to add that it is improbable the phenomenon discovered by Dr. Ker is due to the action of the air contained in the magnetic field, Faraday's observations being sufficient to disprove this. Nor is it likely that the phenomenon is due to the direct action of the lines of magnetic force on the polarised ray. There only remains therefore a change in the molecular state of the polished iron surface when magnetised, as the efficient cause. If the experiment were repeated with a thin layer of silver, or other diamagnetic body, over the pole, then the phenomenon ought not to be observed. Mr. Fitzgerald, of Trinity College, Dublin, has actually tried this experiment with a silvered and a gilt magnetic pole, and, as anticipated, has thus destroyed the effect noted with the unsilvered pole. Further, Mr. Fitzgerald has been led to an extremely simple and beautiful explanation of Dr. Ker's discovery, which he has recently contributed to the Royal Society within the last few days; an explanation analogous to that has been given of Faraday's discovery. Until the Royal Society publish Mr. Fitzgerald's communication we are not at liberty to place it before our readers; which, however, we hope to be enabled to do in a subsequent number.

W. F. BARRETT.

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## TELEGRAPHIC PROGRESS IN AUSTRALIA.

IN no part of the world has telegraphic energy of late years been more signally displayed than in the Australian colonies. The extension of the Eastern Company's system to Sydney seems to have given an impulse to telegraphic progress which has made itself evident by the constantly increasing number of new lines that have been and are being erected. The latest of these is the line connecting South and Western Australia, thus bringing the latter into communication with the other colonies and the rest of the world. The all but impassable desert, the nature of which until within recent years was entirely unknown—has now been crossed, and a telegraph line has been erected over a tract of country which remained a sealed letter until opened up by the energy of Giles, Forrest, Warburton, and Eyre. The work which has here been done during the last few months deserves to be ranked amongst the foremost achievements of telegraphic construction.

The line has been erected, and the work has been carried on along a route which hitherto had baffled the efforts of every traveller, with the sole exception of Eyre, who ultimately succeeded in making his way through it.

The South Australian colony undertook the completion of the line from Port Lincoln to Eucla Bay, upon the great Australian Bight, where the system of Western Australia joined it. Through the energy of Mr. Charles Todd, C.M.G., the Postmaster-General, and Superintendent of Telegraphs to the colony, under whose immediate directions the work has been carried out, the South Australian Government have all but completed their part of the contract. The entire length, 600 miles, carrying a single wire, has been built within the short space of twelve months, and this in the face of obstacles which at first sight appeared to be almost insurmountable. A track of fifty feet wide had to be carried for hundreds of miles through the forest, and even this was but a small part of the difficulties which had to be overcome. The means of transit, it was at first thought, would all but prevent the work from being carried out. All the stores had to be carted, and the lack of water, a great drawback in so many parts of Australia, seemed to effectually bar the way. One hundred horses have been employed and kept constantly at work, although in some cases they were as far off as 145 miles from the nearest water supply.

The line is built throughout, except at crossings where the roads of the future are marked out, of Oppenheimer's iron poles, nineteen feet in length, and each fitted with a lightning-conductor. Sixteen are used to the mile. The ordinary No. 8 galvanised iron wire is run on white porcelain insulators, side brackets of the usual type being employed to support it. The closed system of working is that which is adopted, and the field operator in the van of the constructing party keeps up communication with the nearest battery station, which is 450 miles off. At times the line is put through to Adelaide, and a circuit of over 800 miles in length is thus formed, and has been worked with the utmost satisfaction, not a single hitch of any kind having as yet occurred in connection with it.

## ELECTRICAL CURRENTS THROUGH GLIDING FRICTION OF SOLID BODIES.

IT was shown, some time ago, by M. Quincke, that in passage of a liquid through a diaphragm, electric currents arise, whose direction depends on that of the motion. A similar fact has been proved by M. Zöllner for solid bodies rubbed one against another, and he has made these newly-discovered currents the subject of careful investigation. The main fact observed is this:—If two different bodies, one of which is an insulator, the other a so-called semi-conductor, are moved on one another in gliding friction, there arise in the half-conductor electric currents whose direction depends on the nature and motion of the insulator as follows:—If the rubbed insulator is positively electric, currents arise at the surface of contact or within the rubber, which are parallel, but opposite to the relative motion of the insulator; if the insulator is negatively electric, the currents in question are parallel and

in the same direction as the relative motion of the insulator.

These facts can be simply demonstrated by the following experiment:—A glass cylinder, half coated with resin, is placed so as to be capable of being rotated, with a handle, round a horizontal axis. A piece of soft sheep leather is used as rubber, being stretched on a rectangular piece of caoutchouc, so that thin strips of tinfoil can be pushed between them, which may serve to conduct away the currents. The rubber is kept pressed down on the cylinder by silk bands proceeding on either side to the insulating glass supports. A very sensitive galvanometer is used for observing the currents. If the rubber is on the uncoated part of the cylinder, and the latter is turned from left to right, an electric current passes through the wires, and this is immediately reversed in direction on reversal of the turning. The deflection of the galvanometer rose in one case to ten divisions of the scale. The rubber having next been transferred to the coated part of the cylinder, the phenomena are the same, with this difference only, that with the same direction of turning, the currents have the opposite direction to that in the former case. The deflection here rose, in one instance, to eighteen divisions.

The intensity of these currents seems to depend on much the same conditions as the strength of electric excitation in friction of bodies. Thus, *e.g.*, if the leather is covered with amalgam, the strength of the current is greatly increased; and the spot of light may even be sent off the scale altogether.

It has been long known that with an electrical machine currents and deflections of a galvanometer can be obtained; but the direction of such currents merely depends on which of the galvanometer wires has been connected with the rubber and which with the conductor. The direction of turning does not affect that of the currents. These are merely due to the equalising *(Ausgleichung)* of the electricities separated at the surface of the rubber and the insulator. In the experiments now under study, however, the currents arise from equalising of the quantities of electricity which accumulate *at the two ends of the rubber*, and change their sign on reversal of the rotation.

M. Zöllner has measured the relative strength of these two currents under like conditions, and found that the quantity of electricity equalised by an electric current in the rubber itself, and which, therefore, is lost and without useful effect for the machine, is about 35 per cent. of that which passes on connecting rubber and conductor metallically. This shows that the quantities of electricity in question are by no means insignificant.

Five rubbers of the kind described were placed on the glass cylinder, and their like poles were connected with wires, which again were connected with the galvanometer. Each separate rubber gave, with ten turns of the cylinder, a deflection of about 50 divisions. The five rubbers being connected, it was found that two turns were sufficient to produce a deflection of 50 divisions. Thus, the quantity of friction-currents becoming equalised at each turn of the cylinder, increases proportionally to the number of the rubber-elements.

All these experiments succeed equally when the disc of an electric machine is used instead of a cylinder. The curvature of the surface seems to be without any influence on the phenomenon.

A further series of modifications threw additional light on these friction currents.

A thin leather strip having been taken of such length that its ends could be united under the cylinder (the strip hanging down separated from the cylinder at that part), its inner (amalgamated) surface was pressed on the glass as before, with silk bands, so as to remain fixed when the cylinder was turned. If, now, the two wires of the galvanometer were connected with any parts of the surface of the leather strip, a current was observed, during rotation, whose direction in each case corresponded to a flowing away of the electricity from the two points at which the surface of the cylinder separated from the glass and met it again. The electricity accumulated at the point of separation agreed in its sign with that of the rubbed insulator; that accumulated at the point of union with that of the rubber.

These experiments assume an opposite character, as regards direction of the currents, whenever a resinous surface was used instead of the glass surface. In this case an ordinary unamalgamated strip of leather was used. The currents were reversed in direction, on reversal of the rotation.

A cylindrical glass rod was pushed parallel to its axis in a tube-formed rubber of amalgamated leather, and the ends of the rubber were connected with the galvanometer. Whenever the pushing was sufficiently quick, electric currents appeared, corresponding in direction to the law enunciated, and they changed in direction when the rod was pushed the other way. The same was observed when, within a glass tube, was pushed a glass rod covered with amalgamated leather. If the glass tube was coated on the inner surface with a thin layer of shellac, the directions of the currents were reversed.

These latter modifications of the experiments present an interesting analogy to an older experiment of M. Zöllner, in which electrical currents are shown to arise in distilled water, when it streams through glass tubes. These currents agree, in direction and amount, with those obtained by friction of leather against the shellac-coated interior of a glass tube. It seems natural to assign the same cause in the two experiments, since, according to the researches of Faraday, Peclet, and Quincke, we are warranted in regarding the distilled water, which takes the place of the rubber, as positively electric to the surface of the glass tube.

M. Zöllner also regards M. Quincke's diaphragm-currents as merely a more complicated modification of the electric currents observed by himself in liquids. In room of the narrow glass tubes we have in Quincke's experiments the numerous canals of the porous diaphragm. If it is probable the diaphragm and friction currents have the same cause, the question arises, whether the reciprocal phenomenon of diaphragm-currents, viz., the transference of material particles by the electrical current, is represented by something analogous in the case of friction currents? If so, a rubber, which with amalgamated surface rests on a glass

surface, should be displaced, when an electric current of sufficient tension is passed through it. The direction of this displacement must, according to analogy with the diaphragm-currents, take place always in direction of that electrical flow, which has the same sign as the electricity produced by contact. Now, since amalgamated leather becomes negatively electric through contact with glass, the movement of the leather should be in the direction of the negative flow of electricity.

It is not to be expected that such an effect is realisable with a piece of amalgamated leather. The friction between two solid bodies is so great, that it cannot be overcome by the mechanical work of the electric current. It is otherwise, however, when, in place of the amalgamated leather, a mass of mercury of equal contact surface is employed. If with horizontal position of the glass plate an electric current is sent through the mercury, this should be displaced in direction of the negative flow of electricity. Such a displacement of a mercury mass has, in fact, been observed by M. Poggendorff, and described by him (many years ago) in his paper "On a hew Electrical Phenomenon of Motion." He enclosed a mass of mercury in a carefully-exhausted glass tube, hung horizontally to the pole wires of a Holtz machine, and observed, when the current passed through the tube, that the mercury was set in motion, and went with a considerable velocity from the negative pole to the positive. In whichever direction the current was sent, the result remained the same. We have here evidently a reciprocal phenomenon to the friction currents.

In conclusion, M. Zöllner discusses the phenomena observed in diaphragm-currents, and arrives at the following general law:—In gliding friction of two bodies there are developed, at the surface of contact, electro-motive forces of such a nature, that they produce, under suitable conditions, an electric current which tends to displace the two bodies in opposite direction to their relative motion. [These researches are described in detail in *Poggendorff's Annalen.*]

## THE GRAMME MACHINE.

BY S. E. PHILLIPS, SEN.

MANY have been the attempts to elucidate the principle of the Gramme machine, but I am not aware that anyone has at all succeeded. Any idea of a continued flow of magnetism in the circular iron core must be utterly discarded, and the exaggerated notions of a continuous flow of induced electricity must be reduced to a mean of many inequalities. In both these respects, it differs but little from the old forms of magneto-electric, or electro-magnetic machines.

As good illustrated descriptions are plentiful, one need not go over that ground, and may assume a familiarity with the ordinary principles of inductive machines.

In the old Clark machine, the neutral points, where the direction of induced current changes, are theoretically at the poles. In the Gramme ring, that change takes place theoretically at right angles to the poles; and to understand how and why this is will involve a mastery of the subject.

In all cases, we will suppose motion to the right, in the upper half; and therefore to the left, in the lower portion.

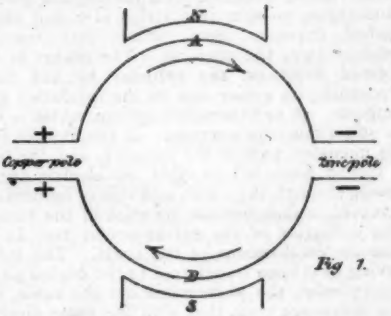


*Fig 1.*

In the old machines, an ordinary electro-magnet passing from the neutral point A would have a current induced by diminished northness, and continuing towards B, the same direction of current, as due to increasing southness; and oppositely on the lower half; whereas in the Gramme, increased northness on the left gives one current, which has a maximum at A, and decreasing northness (on the right) *gives the same current*, which dwindles to nothing at the midway neutral point, where a few coils are sacrificed, and the current is taken off. From this point, an opposite current is set up in the coils, with a maximum at B, and dying out at the opposite side.

Here, then, is a double paradox for explanation. 1. How is it that two opposite currents can be taken off at one pole? 2. How is it that *increasing* northness and *decreasing* northness both give one direction of induced current.

Estimating the separate coils, we might say that in the upper half they give + or copper currents, while those in the lower half give — or zinc currents; but as a copper current in one direction, and a zinc current in the opposite, are only different expressions for *the same thing*, so it will be seen that all through, direction of motion, with character of winding, will explain all.

Whether we speak of the upper and lower arrows as indicating + and — currents, or not, is quite immaterial, so that we understand what really subsists; and if we label the ends of all the coils *a* and *b* consecutively, it is evident that at the zinc pole (right hand side) we are drawing off current in the upper half, from the *b* ends, and in the lower half, from the opposite or *a* ends.

It is also evident that a (so-called) + current, moving to the right, in the upper half, must involve a + pole or potential at the left hand side, and a negative potential at the right; also that a (so-called) — current in the lower half would involve the same potential at the two ends.

Thus we see that the ordinary explanation of the two halves, being like two batteries joined up for quantity, is right *only in the effect* produced.

Fig 2.

In that case we have currents, plates, &c., &c., in both alike, whereas in the Gramme we have opposite motion, opposite current, and virtually an opposite character of winding.

The same peculiarities will explain the second point of paradox.

In the ordinary machines the magnet A has an end-to-end motion; but in the Gramme the coils have a transverse position, in passing the motor poles; hence we must ever bear in mind that the two things involve a different category of influence.

A in passing from *c* to *d* gives one current, from *d* to *e* and *f* the opposite.

B moved from *c* to *d* gives one current; from *d* to *e* the *same current*, and *e* to *f* the opposite current.

For those who like experimental demonstrations, it may be well to follow the tedious experiments of M. Gaugain, or, better still, to provide a bar magnet and sliding coil, &c., &c.; but it is unquestionably best to have such a clear grasp of these relations, as to see beforehand that the known results should and do take place.

To such there is no paradox in these opposite effects from the same causes, because they are ever associated with opposite motions, or virtually opposite windings; and the proof is so plain as not even to require experiments.

*Increasing* northness gives one current *c* to *d*. *Decreasing* northness gives the same current *d* to *e*, and so it should; because the winding is virtually opposite.

Increasing northness (with the *b* end of the coil towards N), whether on the right hand or the left, or however varied, can only produce one simple current of induction in one direction; but in the Gramme, if the *b* end of the coil is towards N in *c* - *d*, the opposite will result in *d* - *e*.

Whether the motion be on the right or the left is as nothing provided the conditions are similar; and if this be clearly understood, the whole paradox vanishes, and all becomes clear and simple.

As to the continuous character of the current, the soft iron ring changes polarity twice in every revolution, and the consequent friction of atoms developes heat, precisely as in all other arrangements; and assuming 54 coils, then the electromotive force at any moment is a mean of about 25 potentials; the midway coils having a maximum force, and the others dwindling to zero at both sides.

The motor-poles of a Gramme machine may be either permanent magnets or electro-magnets; but the principle of using soft iron, and getting all the power from mechanical motion, is no essential part of the Gramme.

## Notes.

WE have pleasure in informing our readers that a photographic portrait of Sir William Thomson is in course of preparation for the TELEGRAPHIC JOURNAL, and will appear, along with a biographical sketch of the eminent physicist, in our next number.

It is a well-known fact that muscles contract under the influence of electricity, and it is long since experiments were first made in the stimulation of dead bodies by this means. Some curious phenomena have been obtained in this way. Recently, Dr. Kappeler, of the hospital of Münsterlingen, has added some new observations on the subject. He subjected twenty corpses to the action of various electric currents, and noted the rate of disappearance of the electro-muscular contractility. In persons emaciated by long chronic maladies, this disappeared much more rapidly than in robust individuals, or those who had had acute maladies. It disappeared five quarters of an hour after death, at the quickest, and six-and-a-half hours at the slowest. It is in cases where a rise of temperature is observed after death (which are not extremely rare), that the electric contractility persists longest. The importance of this sign of death is evident if we reflect that the contractions under electricity continue intact so long as there remains the least life. In the most prolonged faints, in the deepest lethargies, in all the varieties of apparent death, poisonings by carbonic oxide, chloroform, or narcotic substances, this valuable sign can be had at will, so long as real death is not a *fait accompli*. The fact of death, too, can be thus ascertained without the necessity of awaiting other certain signs of death. Some interesting cases in this connection are related by Dr. Kappeler in his paper, which appears in the *Bibliothèque Universelle* for November.

According to the recent report of the Western Union Telegraph Company, the central office in New York has during the past year been connected with the branch offices at No. 14, Broad-street, No. 134, Pearl-street, and the Cotton Exchange by pneumatic tubes. The tubes are

made of brass, each 2¼ inches internal diameter and ⅛ of an inch thick, and are laid under the pavements in the streets at a depth of three feet. Messages are sent from the central office to the several branch offices by compressed air, and from the branch offices to the central office by atmospheric pressure or vacuum. The motive power is furnished by a 50-horse power duplex engine, situated in the basement of the central office, which operates two double-acting air-pumps communicating with the compressed and vacuum mains terminating in the operating-room. These are connected to the tubes extending under the streets by means of double sluice valves, which are so constructed that carriers containing messages may be sent through the tubes in either direction by turning a cock connected with the compressed or exhaust air-mains. With the usual pressure employed—6 lbs. to the square inch—the time occupied in transmitting a box or carrier containing messages between the central office, corner of Broadway and Dey-street, to the office at No. 14, Broad-street (700 yards) is about forty seconds; and between the central office and the offices at No. 134, Pearl-street and the Cotton Exchange (900 and 1,100 yards) about one minute and five seconds and one minute and twenty seconds respectively. The operation of the pneumatic tubes is very satisfactory, resulting in a material saving of both time and money. The total cost of the system is less than 30,000 dollars, and about one-half of the outlay will be saved annually, to say nothing of the saving in time, by the decreased cost of performing the service by pneumatic tubes between these stations as compared with the former cost by wire. There are several offices in the city where the traffic is large enough to warrant their connection by pneumatic tubes with the central office, and it is probable that the system will be extended to some of them after its value has been more fully ascertained.

The Paris correspondent of the *Standard* says some inventor has found out a means of sending portraits by telegraph. The *modus operandi* has not yet been disclosed, but experiments have been made by the police authorities of Paris and Lyons, and, it is said, with complete success. The portrait of a Lyons official was forwarded from Paris by the new telegraphic apparatus, and at once recognised. In return, the Lyons police telegraphed to Paris the portrait, accompanied by the usual description, of a clerk who had just absconded with his master's money, and the Paris police were enabled, thanks to the telegraphic portrait, to arrest the thief on his alighting from the train at the Lyons railway station. Various other applications of this invention will suggest themselves.

On the evening of the 7th inst. Dr. W. B. Carpenter lectured at the London Institution on "Mesmerism, Odylism, Table-turning, and Spiritualism, considered historically and scientifically." Among other things he referred to Dr. Braid's experiment with the man who saw flames coming from a magnet in the dark, on the existence of flames being suggested to him. The magnet was then secretly shut up in a box, but he still saw the flames where they had been before. Lord Lindsay took Mr. Home into his library, and Mr. Home saw flames coming out of a magnet in the corner. There were many ways in which he might have ascertained before that the magnet was there, and the true way to perform the experiment was to have, not a natural magnet, but a bar magnetised at irregular intervals electrically by an operator in another room, so that count being taken of the times when Mr. Home said he saw flames, and of the times when the bar was magnetised by the current, it might be seen whether or not they corresponded.

It appears that great difficulties were recently raised by the Servian authorities in the way of despatching telegrams from Belgrade relating to war movements. The consequence was a loss of many hundreds of pounds to the Servian Government, but a great gain to journalism and the public. The correspondents had to go and telegraph from Semlin, in the Austro-Hungarian dominions, reached by steamer from Belgrade in a quarter of an hour. This is a very small town, but its telegraph office is of European reputation. Never in any instance did it fail to meet the large call made on it. Every evening for nearly five months it had to deal with telegrams written in the English, French, German, Italian, Russian, Polish, and Servish languages, and the rapidity and accuracy with which those messages were transmitted was simply marvellous. There was not an operator in the office who understood a word of English, and yet the account of the battle of Alexinatz, which appeared in the *Times* of Sept. 4, and occupied nearly four columns, was transmitted from Semlin without the mistake of a single word. Long telegrams handed in at the Semlin office so late as eleven o'clock at night, were received by the Vienna correspondent of the *Times* before midnight, and by means of special wires of that paper from Vienna to Paris, and from Paris to London, reached the *Times* office in

time for publication in the earliest editions of the following morning. Great credit is due to the administration of the Austro-Hungarian Telegraph Department and to the Semlin officials for such excellent arrangements and work.

The monthly abstract of the Eastern Telegraph Company shows that the average rate of transmission, in November, of messages from Calcutta to London, was 37 minutes; from Bombay, 25 minutes; and from all other Indian places, 47 minutes.

A conversazione of the Society of Telegraph Engineers is to be held at Willis's Rooms on Monday, the 18th inst.

An electric governor for marine engines was recently described by M. Lawerence Hill before the Scottish Institution of Engineers and Shipbuilders. In this apparatus, whenever the water leaves the screw more than is safe, and before the engine can increase in velocity, the magnet shuts the throttle-valve; and again, whenever the screw is covered afresh with water, the steam is quite as promptly let on. The contact making part of the apparatus is fixed to the outside plating of the vessel, and a small button rests on a diaphragm on which the water of the sea impinges. A ¾-inch hole is bored at the stern near the screw, and over it this part of the apparatus is fitted, which, according to the height of the water above the orifice, cuts off or sets on the electric current. This current magnetises the magnet which is carried on the crank shaft, one arm being connected with the throttle-valve. So long as no current is passing, the magnet is kept back, and the valve open by means of a weight; but whenever it begins to pass, the poles of the magnet instantly adhere to the revolving shaft, and the magnet is carried round for, say, one-eighth of a revolution, when it is brought up by means of a stop. The valve is shut so long as it is kept to the stop, but when the contact is broken, by the water again covering the screw, the magnet instantly falls back to its first position, and opens the valve. In the first machines it was found that the residuary magnetism occasionally prevented the magnet from freeing itself, and thereby delayed the letting on of the steam. This is now remedied by reversing the current. A single Leclanché cell is now quite sufficient.

One of the most remarkable feats in telegraphy ever performed, says an Albany paper, was executed in the Albany and New York offices a short time since. It was the transmission of a tabulated statement, embracing five columns of figures with the usual preceding column of reading, headings, dash lines, footing, &c., to the Associated Press of New York, from this city. We think this feat was never attempted before. The chief operator securing the co-operation of the chief in New York, and selecting their most experienced telegraphers, made the effort and accomplished it perfectly. On reaching the footings the operator in New York said he could give them as well as Albany, and running up the columns he had received, sent them correctly.

In a supplementary number of the *Philosophical Magazine* for December, Mr. R. Sabine describes some curious observations on electricity disengaged between mercury surfaces; and on the motions produced in mercury by deoxidation. He concludes from his experiments (1), that the electricity disengaged between pure mercury surfaces (when not hydrogenised) is due to different *states* of oxidation; (2) that the motions observed to take place in mercury electrodes under water (or dilute sulphuric acid), are due to the displacement of the surface corresponding to the different atomic volumes of the metal and its suboxide (or suboxide and sulphate); (3) that the pumping action of a column of mercury in a tube or narrow channel is due to rapid circulation caused by such displacement; (4) that these motions are not due to change of either constant of capillarity or adhesion; and, finally, (5) that we may give a negative answer to Draper's question—viz., Is capillary attraction an electrical phenomenon? (In the same number will be found a paper by Mr. Lodge, "On a Mechanical Illustration of Thermo-Electric Phenomena.")

An important work, entitled, "*Traité d'Electricité Statique*," by Prof. Mascart, of the College of France, has been recently published in Paris. In the first of the two volumes, M. Mascart studies the laws of electric actions, the laws and phenomena of electric loss and distribution, the theory of electrical phenomena and its applications, and instruments of observation and measurement. This last, and a chapter on electric influence and consideration are specially valuable. The second volume treats of electric discharges (conductive and disruptive discharges), experiments in electricity, and properties of the spark. There is, further, an interesting chapter on electric machines, and the last and principal chapter in the work is devoted to the "Sources of Electricity." M. Mascart, like most modern physicists, adopts the theory of contact, and from a comprehensive *resumé* of the phenomena he endeavours

to show, that not only has this theory the advantage of being the simplest, but that it alone can give in all cases an explanation of the electrical phenomenon produced. (The work is published at the Librairie G. Masson, in Paris.)

The Oriental and American Telegram Company, Limited, have recently purchased Flamant's old-established North American Telegram Agency, and this branch of the business, which it is intended greatly to extend, will be conducted under the immediate superintendence of Mr. Flamant, whose services have also been secured by arrangement.

The Indo-European Telegraph Company state that the cable between Singapore and Java is restored, thus re-establishing direct telegraphic communication with Java, Australia, and New Zealand, viâ Teheran. Telegrams must be marked "viâ Indo."

Greville's Australian Telegram Company state that the cable to Australia is quite restored, and that messages can be sent through them direct, marked "viâ Greville's Australian Telegram Company."

TRAFFIC RECEIPTS.

West Coast of America Telegraph Company, for four weeks ending 23rd September, 1876, £2,432.

Cuba Submarine Telegraph Company, for November, estimated production, £1,600, against £2,353 in November, 1875. The traffic receipts of September realised £2,029.

Direct Spanish Telegraph Company, for November, £729, against £1,697 in November, 1875.

Eastern Telegraph Company, for November, £35,485, against £30,478 in November, 1875.

Eastern Extension Australasia and China Telegraph, for November, £24,611, against £13,501 in November, 1875.

Great Northern Telegraph Company, for November, 410,177 francs, against 270,844 francs in November, 1875.

Direct United States Cable Company, for week ending 2nd December, £3,550; 9th December, £3,850.

Anglo-American Telegraph Company, December 4th, £1,300; 5th, £1,600; 6th, £1,700; 7th, £1,920; 8th, £1,820; 9th, £1,700; 10th, £470.

Western and Brazilian Telegraph Company, for November, £10,856, against £9,860 in November, 1875.

## Proceedings of Societies.

### PHYSICAL SOCIETY—2ND DECEMBER, 1876.

Prof. G. C. FOSTER, President, in the chair.

THE following candidate was elected a member of the Society:—G. Waldemar von Tunzelmann.

M. JANSSEN made a brief communication, in French, with reference to a method which he has proposed to the Académie des Sciences for ascertaining whether planets really exist between Mercury and the Sun. After mentioning the importance of photography from an astronomical point of view, he explained his reasons for hoping that a series of solar photographs, taken regularly at intervals of about two hours, at a number of places on the earth's surface, would enable us to determine this question, which is now agitating the scientific world, since any spots which crossed the sun's disc would be at once registered. As it is necessary that such observations be made at several places, and in several countries, M. Janssen hopes that other countries besides France will ere long arrange to have such a series of observations taken, and he considers that in a few years the circumsolar regions would thus be explored with a certainty which could not possibly be attained by any other method. He exhibited some of the original photographs taken in Japan of the transit of Venus, and explained the advantage of placing a grating in the focus of the camera in order to eliminate distortion.

MR. CROOKES showed the spectrum of a small specimen of chloride of gallium, which he had received from its discoverer, M. Lecocq de Boisbaudran. The discovery of this metal is of peculiar interest, as M. Mendeleeff had previously, from theoretical considerations, asserted it to exist, and had also correctly given some of its chemical and physical properties. The most prominent line in the spectrum was a bright line in the blue, somewhat more refrangible than that of indium.

MR. LODGE briefly described a model which he has designed to illustrate flow of electricity, &c., which is fully explained in a paper in the *Philosophical Magazine* for November, and he showed how similar considerations can be applied in the cases of thermo-electric currents. The model in its simplest form consists of an endless cord passing over four pulleys, and on one side of the square thus formed it passes through a series of buttons held in their positions by rigid rods or elastic strings, according as they represent layers of a conducting or non-conducting substance. When considered in connection with thermo-electricity, the buttons are assumed to oscillate on the cord, and if they move in one direction with greater velocity than in the other, the cord will tend to move in the former direction. Now, at a junction of copper and iron, since the metals have different atomic weights, and their kinetic energies are equal, the velocities must differ on each side of the junction, and an unsymmetrical oscillation of the molecules must ensue, analogous to that assumed by Mr. Stoney to take place in Crookes' radiometer, and the cord, or electric current, will advance when two junctions are at different temperatures. Mr. Lodge showed experimentally that for a given difference of temperature the maximum thermo-electric current is obtained when one of the junctions is at 280° C, and beyond this point the amount of deflection decreases. This fact led Sir W. Thomson to discover the convection of heat by electricity; that is, if we have a circuit composed of copper and iron, and one of the junctions be at the above temperature, the current in passing from hot to cold in the iron, or from cold to hot in the copper, absorbs heat. This fact was experimentally illustrated by Mr. Lodge. A strip of tin plate is symmetrically bent, so as to nearly touch the two faces of a thermopile, and is heated at the bend by steam passing through a brass tube on one side (not end) of the thermopile, and kept cold by a current of water on the other side. As the arrangement is symmetrical, no current is found to pass through the thermopile, but when a powerful voltaic current passes through the strip of metal, a distinct deflection of the needle is observed in accordance with the above law.

# Electrical Science in Foreign Journals.

## COMPTES RENDUS OF PARIS ACADEMY.

### No. 21: 20TH NOVEMBER, 1876.

*New Researches on the Chemical Phenomena produced by Electricity of Tension.* BY M. BERTHELOT.

HE examined the relations between these reactions and the sign or the tension of the electricity. A sort of Leyden jar (tube with two armatures, hermetically sealed at a lamp) had its own interior armature charged by means of a platinum wire with positive electricity in the form of sparks from a Holtz machine; its exterior armature connected with that of a like tube, whose interior was similarly charged with negative electricity. With oxygen in the tubes, ozone is formed under influence of both electricities. In action for six hours, the two electricities gave similar effects, tending to the limit of 8 to 8·5 hundredths (in ozone) of the original oxygen. If arsenious acid be previously added to destroy the ozone, more oxygen is transformed in a given time. With sparks 1 ctm. long and a condenser, 5 to 6 per cent. of ozone will be had in six hours; with sparks (though more numerous) ½mm. long, not more than one to two-thousandths of ozone. The proportion of ozone always decreases more quickly than the length of the spark. In no case of influence-experiments with the Holtz machine was the least trace of nitrous compounds observed, in operating with nitrogen and oxygen, dry or moist. But *acetylene* appears in notable quantity in the vapours of organic compounds, enclosed with nitrogen. With both electricities, having strong tension, ether furnishes much acetylene, benzine less. The absorption of nitrogen by organic compounds occurs equally under influence of both electricities, and as distinctly with the weakest as with the strongest tensions, but in a longer time. In such cases there is formed neither ammonia, nor nitric, nitrous, or cyanhydric acid. With very weak tensions, the fixation of nitrogen with paper was especially abundant, less with ether, and still less with benzine. The author is further studying the influence of the incessant variations and sudden alterations in the electric tension.

*Organisation of a new Meteorological Observatory on Monte Cavo; Meteorological Observations in the Neighbourhood of Rome.* BY P. SECCHI.

This is the ancient Mons Albanus; it is 953m. above the sea level. The instruments are kept in a monastery: they are a Fortin barometer, a thermometer, psychrometer, thermometrograph (maximum and minimum), pluviometer, and weathercock; an anemometrograph is shortly to be added.

*On the Phenomenon of the Black Drop.* BY M. ANDRÉ.

IN the mechanism for producing an artificial transit, one of the poles of a battery communicates with the planet Venus, the other with the sun's limb. At the moment of contact, a current flows, and is registered on a Breguet chronograph. On this is also inscribed parallely the hour as given by a Winnerl pendulum, and the mark, when the observer presses down a Morse key, on observing contact.

*Experiments on the Pneumogastric and on Nerves supposed to be Inhibitory.* BY M. ONIMUS.

EXCITATION of the pneumogastric with induced currents, for a few seconds, is known to stop the heart. Hence an inhibitory function has been attributed to this nerve. But M. Onimus shows that if the rate of succession of the excitations be reduced low enough, the induced current will actually provoke contraction. Thus, if an animal be poisoned with curare, so that the heart-beats have come to be only 40 or 50 a minute, one may, with an induced current produced each second, and applied to the pneumogastric or the heart, excite exactly 60 heart-beats in a minute. Accordingly, these supposed inhibitory nerves of vegetative life are brought under the general laws of action of all nerve-fibres; the phenomena of stoppage only occurring when the excitations become too numerous and too rapid.

*On some Peculiarities of Lightning.* BY M. RENOU.

HE describes—1. A case of beaded lightning which he witnessed in 1859. 2. Purple or violet flashes of the tint of electricity traversing air rarefied to 3 or 4mm. of mercury. These discharges were probably at 25,000 to 30,000 metres altitude. 3. Lightning, without thunder being heard. This may occur directly overhead. 4. An observation regarding the distance at which thunder may be heard. He heard it one quiet evening at 40 kilometres distance.

### No. 22: 27TH NOVEMBER.

*On Crystals of Magnetic Oxide of Iron formed during the Roasting of a Spathic Ore.* BY M. BOUSSINGAULT.

*On a Remarkable Fall of Hail, observed at Gutta-Ferrata.* BY P. SECCHI.

THE hailstones were formed of groups of crystals five or six sided, with pyramidal ends, round an irregular mass of ice. The groups weighed 40 to 60 grammes; certain blocks 300 grammes. The cloud was like a huge ball of cotton or wool moving from N.W. to S.E. It showed a whirling movement, and gave out a dull crackling noise, like that from collision of hard bodies. There were continuous and intense electric discharges in the heart of it. P. Secchi considers that in general electricity is not the cause, but the effect, of hail.

*On a New Electric Repulsion and its Application to the Theory of Comets.* BY MM. REITLINGER and M. URBANITZKY.—See p. 313.

*On the Portative Force of Horse-shoe Iron Magnets.* BY M. VAN DER WILLIGEN.

To saturate his magnets, he places them vertically with their poles on a Ruhmkorff coil, whose circuit he opens and closes three or four times successively. After the first opening, he slides the magnet carefully towards the edges of the polar planes of the electro-magnet. Then he places the well-cleaned support before this magnet, inclining the latter slowly, while its poles are still in contact with those of the electro-magnet. Immediately the support has joined the magnet, this can be raised without effort; its portative force is then nearly a third greater than the ordinary permanent portative force of M.

von Wetteren's best magnets. This state of supersaturation forms the starting point of his memoir. His empirical formulæ adapted to difference of form, are

$$P = A\,O\,\sqrt{s}\,\sqrt[4]{\frac{l}{\sqrt{s}}} \qquad (I)$$

$$p = B\,O\,\sqrt{s}\,\sqrt[4]{\frac{L}{\sqrt{s}}}\cdot\frac{L}{l} \qquad (II)$$

in which A and B are co-efficients to be determined by experiment, O and $s$ are the circumference and the surface of the polar faces; and L and $l$ are the length and the reduced length of the magnet. Experiments with thirty-six magnets, simple and compound, rendered it probable that (I) is the general empirical formula for the state of supersaturation, (II). is the general empirical formula for the state of permanence of simple magnets, while for them A = B. For simple magnets is added (III) $p = P\left(\frac{L}{l}\right)^{\frac{4}{3}}$. The free magnetism for the magnet closed and supersaturated is less than for the magnet closed and permanent; the free magnetism in the closed and permanent state is to the magnetism in the open state nearly as 3 to 10, a proportion becoming more and more constant as the magnet approaches a definitive permanence, through successive detachments of the support.

*Explanation of Actions at a Distance; Gravitation; Electric Actions.* By M. PICART.

ALL action at a distance can be explained by matter and motion. In electric actions, the material molecules, grouped together by their mutual attractions to form bodies, condense etheric atoms round them, forming atmospheres more or less dense. The increase or diminution of the density and elastic force of these atmospheres constitutes the positive or negative electric state of the body. Between these atmospheres and the material molecules at a distance, there must be a *gravitation* similar to that of two material molecules; between two *condensed* atmospheres of ether there must be a repulsive action, arising from the necessary increase of velocity of the atoms moving in the two directions from one atmosphere to the other, and which produce in each, on the side they strike against, an increase of pressure tending to separate the two, and proportional to the inverse of the square of their distance.

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CARL'S REPERTORIUM FÜR EXPERIMENTAL PHYSIK. XII. BAND. 5 HEFT.

*On the Curve of Tension of Saturated Water.* By Dr. OSCAR FABIAN.

THIS name is given by Prof. Zenner to the curve representing the connection between pressure and melting temperature. Dr. Fabian shows the rise of temperature of a mixture of ice and water under the recipient of an air-pump, by means of a delicate thermo-electric arrangement. One vessel (A) connected with an air-pump, and half filled with ice and water, is placed in an open vessel (B) containing the same mixture. In the side of the interior vessel is fixed a thermo-electric battery the wires of which proceed to a galvanometer. When the air is rarefied in A, the quantity of ice increases, while that of water diminishes; the liberated heat of freezing raises the temperature of the mixture; hence the inner surface of the pile is heated and a deflection produced in the galvanometer. Several other experiments are described.

*Monthly Average of the Magnetic Declination and Horizontal Intensity observed at the Observatory of Prague in the Year* 1875.

*On the Magnetism of Soft Iron Cylinders, with an Appendix on the Magnetism of Steels of Different Hardness.* By Dr. CHRISTOPH RUTHS.—(An abstract).

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## ELECTRIC REPEATERS FOR RAILWAY SIGNALS.*

BY W. LANGDON, M.S.T.E.

IN order that signalmen and others may accurately know the condition of the signals worked by them for the control of the traffic on railways, it would appear that one of two courses is needed. Either the signals themselves shall be of such a nature as to be beyond the influence of the elements, or some means must be adopted by which the state of the signal—whether it be the arm or disc by day or the light by night—may be known to the man who is responsible for its working.

The question of altering the form of signals throughout any line of railway must be dismissed: it would be an expensive and troublesome matter, while it at the same time remains to be shown that a system could be devised which would prove independent of wind and weather. The present system is that which would recommend itself to every practical mind, although it cannot be denied that its working may be more or less affected by every change of temperature. The expansion and contraction of the wire working the signal under the varying influence of the temperature may often be such that although the lever in the signalman's box is moved into its proper position, the arm at the distant signal refuses to obey it. The signalman remains in ignorance of the fact, and disastrous consequences ensue. But let a signal work ever so badly, means may be taken to guard against its inoperation proving a source of danger, provided only its condition is made known to the signalman. This desirable end is attained by means of the Electric Repeater.

There are two forms of electric repeater—that for the arm or disc, and that for the light. The arm-repeater was introduced by Mr. W. H. Preece, who recognised the necessity for it, in 1865 temporarily applied one of his semaphore block-signal instruments to a distant signal near London. A combined arm and light instrument, the joint invention of Mr. Preece and Mr. Warwick, followed shortly afterwards. Instruments of this description are now in use on various railways, but their introduction has been neither so rapid

* A paper read before the Society of Telegraph Engineers

nor so great as recent circumstances plainly indicate to be necessary.

Passing by the mechanical and electrical arrangements requisite for an electric repeater (described fully by the author) the greatest principle resolves itself under the following heads:—

1. The necessity for the employment of such repeaters.
2. To what signals they should be applied.
3. The nature of the indication.
4. The point of connection with the signal.
5. Form of instruments or indication.
6. Electrical principles.

As regards the necessity for the employment of electric repeaters, the accident at Abbots Ripton forms perhaps the most powerful argument that could possibly be adduced in favour of their adoption. A snowstorm hid the signals on that occasion from the signalman's view; it prevented the signals from working efficiently, and an accident was the natural result. Had the signalman known that the signal did not obey the lever and rise to "danger," he could have taken such steps as would have prevented the accident. He had by him his flags, his lamp, and his fog-signals; but in the full belief that the signals had responded to the lever, he used none of them.

Further, the employment of electric-repeaters is a good disciplinarian. The regularity in the character of the signals which would otherwise be absent is attended with the most beneficial results, and the warning given by the repeater of the working of the wire prevents the state of the signals from being anything else than what it ought to be.

Admitting, then, the necessity of employing electric-repeaters, the question arises, "To what signal should they be applied?" The immediate reply is, that their chief value lies in their application to the distant signal. But it is an open question whether starting or home-signals, when worked some little way off from the signal-box, should not in like manner be repeated back to it. Take the working of a railway in a dense fog—the most adverse condition, perhaps, in which railway traffic can be carried on. The importance of the due action of every signal cannot be over-estimated, and it becomes, to say the least, a most desirable thing that on such an occasion the signalman should have accurate information of the state of every signal under his command. It would doubtless be a wise policy to have every signal which is liable to be in any way obscured from the signalman's view repeated back to him.

Diversity of opinion exists as to the nature of the indications which should be given. Some are of opinion that the repeaters should simply show when the signal is at "danger," others that it should indicate both "on" and "off," whilst many will be found to affirm that not only should three positions "danger," "caution," and "clear" be made known, but the intermediate positions as well should be shown. In looking at this part of the subject, it would be well to bear in mind what is the real point of danger. It clearly is that when a signal which is intended to be at "danger," and which so far as the means of working it are concerned has been put to "danger," does not stand at danger but shows the line "all clear." It is then that the signalman should be made aware of the fact that his signal is not on; if it does not stand at "off" when it ought to be off, but still remains on, no positive danger will arise. An approaching train in such a case as this would, finding the distant signal at danger, after a time draw slowly on to the home-signal, and seeing it at "all clear" would proceed on its way, the driver indicating to the signalman that the distant signal was at danger and required looking to. A system of this description would require only one wire for its operation, and the battery would be at work only during the time that the signal is at "danger." To show when the signal is "on" and "off," or to show when it is at "danger," "caution," and "clear," necessitates the employment of two wires or fixing the battery at the signal post where it may become frozen in hard weather.

It is to those parts which constitute the actual signal, namely, the arm or disc by day, and the "spectacles" by night, that the connection should be made. Hitherto no connection has been attempted with the "spectacles"; the attachment has been made to the arm instead, or to some part of the rod or lever working the arm. Yet the connection ought undoubtedly to be made in such a manner that the action of one shall be made dependent on the action of the other—a result which might be attained at the expense of an additional pair of springs. It may be argued that if the lever has its due action, that of the arm is bound to follow; but the possibility of a bolt giving way, or the arm working loose in its socket should not be overlooked, and ought assuredly to be provided against.

The form of instrument or indication may vary as much as that of the block instruments employed in railway signalling. Miniature semaphores, indicators, or pointers, small shields with the words ON and OFF brought to an aperture in the face of the instrument, are all employed. For the *light* similar arrangements are made use of, with the addition that in some a bell is set ringing soon after the lamp goes out, and continues to ring until the light is restored. There is probably very little to choose from the individual fancies of each engineer, although that system would seem to have an advantage in which a form of instrument is employed according with the out-of-door signal, and requiring merely a knowedge of its working to tell at once "danger" from "clear" or "caution."

The electrical arrangement should be such as to be undemagnetisable, and free from the danger of having its indications reversed by any atmospheric causes. Its normal condition should be showing "all clear or caution;" its "danger" signal should be produced by the action of the current. The reasons for this are well-nigh self-evident; for if the normal condition were that of "danger" in place of "all clear," any defect in the wire or apparatus would show the signal to be at "danger" when it might not be in that position. Gravity, upon this principle, may be made to show the all-clear signal, and the action of the current the danger-signal.

For the proper working of a system in which the electric-repeater is employed, every signalman

should be instructed that wherever a repeater is in use he must never assume that because it does not act the repeater is wrong; he must on the contrary conclude that it is his signal which is wrong, and not rest satisfied until he is perfectly assured to the contrary.

## SIMULTANEOUS IGNITION OF MINES.*

To produce the maximum effect in removing obstructions, and in other similar work, both civil and military, pertaining to the duties of the Corps of Engineers, it is often desirable to cause the simultaneous explosion of many mines; or, sometimes, the simultaneous ignition of many fuses distributed throughout the charge of one large mine. In the present state of science this will always be effected by electricity; and the form usually preferred will be the voltaic or magneto-electric current acting upon numerous low tension fuses. Such fuses may be united either in series, *i.e.*, fuse connected to fuse in a single circuit, or in derived circuits, *i.e.*, each fuse so connected to both of the main lead wires, or in some combination of these two methods; and the maximum number which it is possible to explode simultaneously by a given battery or magneto-electric machine will vary according to the grouping adopted.

### GENERAL THEORY.

I am not aware that any mathematical investigation has been made to determine the rules which should govern the engineer in arranging such groups; and as the matter is not without practical importance, in ordinary as well as in large blasts, I have analysed the problem with the following results. Let:

$E$ = the available electro-motive force in volts.
$R_1$ = the corresponding internal resistance in ohms.
$C$ = the current in webers needful to fire one of the groups connected in series—all such groups being supposed equal in electrical resistance.
$L$ = the resistance in ohms of the main lead wires connecting the source of electricity with the groups.
$F$ = the resistance in ohms of each fuse at the instant of explosion. This includes the increased resistance due to the heating of the fine wire bridge, and also the resistance of the needful local connections.
$N$ = the total number of fuses which can be exploded simultaneously.
$n$ = the number of fuses connected in series to form a single group.
$\frac{N}{n}$ = the number of such groups connected in derived circuit.

From well-known electrical laws, the following general equation for the blast can be stated—each member representing the total strength of current necessary to cause the explosion:

$$(1) \qquad \frac{N}{n} C = \frac{E}{R_1 + L + \frac{n F}{\frac{N}{n}}}$$

Solving this equation with respect to N, and finding its first differential co-efficient regarded as a function of n, we have:

$$\frac{d N}{d n} = \frac{E - 2 F C n}{C (R_1 + L)}$$

Placing the second member equal to zero, and combining the resulting equation with eq. (1) we have for the conditions of the desired maximum:

$$(2) \qquad N = \frac{E_2}{4 F C_2 (R_1 + L)}$$

$$(3) \qquad n = \frac{E}{2 F C}$$

$$(4) \qquad \frac{N}{n} = \frac{E}{2 C (R_1 + L)}$$

As a check upon the computation, the following value of C, derived from eq. (1), should be nearly the same as the assumed value. They probably will not be identical—since fuses and groups cannot be subdivided, and fractions in n or $\frac{N}{n}$ must, therefore, be ignored:

$$(5) \qquad C = \frac{E}{\frac{N}{n} (R_1 + L) + n F}$$

It is evident that these equations furnish a mathematical basis for a thorough practical discussion of the subject, for not only do they reveal the maximum number of simultaneous explosions which can be obtained with any particular generator of electricity, type or fuse, and kind of lead wire, but they also indicate the relative importance of the different constants, and hence point out the principles which should control the selection of apparatus and meterials for any difficult blast. Of these constants, the numerical values of E and $R_1$ vary with the nature of the generator of electricity: those of F and C depend upon the construction of the fuse; while L is fixed by the conductivity and cross section of the metal selected for the main lead wires.

The first glance at Eq. (2) shows that N increases directly with $E_2$ and inversely with $C_2$ F $R_1$ and L—hence, as the squares of E and $\frac{1}{C}$ enter the formula, particular attention must be given to making these quantities as large as possible.

Again, a little consideration will reveal the extreme importance of making L disappear in these equations. This can and always should be done, either by using rods so large as to offer no sensible resistance to the current, or by causing the several groups to diverge at the poles of the battery, and increasing F accordingly. In this case, Eq. (4) may be put under the form:

$$\frac{N}{n} = \frac{1}{2 C} \times \frac{E}{R_1}$$

Now, since E and $R_1$ are both directly proportional to the number of elements coupled in series, this equation reveals the curious fact that when all the cells of a voltaic battery are so coupled, the proper grouping of the fuses is quite independent of the number of cells; *i.e.*, the proper number of groups to be used in derived circuit is constant, no matter how many cells are coupled in series. Hence, so far as the number of groups is concerned, the relative

* A Paper read by Bvt. Brig. Gen. Henry L. Abbot before the American National Academy of Sciences, April 18th, 1876.

merit of different types of battery is in the direct ratio of the numerical values of the quotient $\frac{E}{R_1}$ for a single element.

But Eq. (3) shows that, with any type of battery, the number of fuses which can properly be placed in each group is directly proportional to the number of cells coupled in series; also, that the relative merit of different elements in this respect is directly proportional to their electro-motive force per cell.

This analysis makes it clear that, in choosing a battery for a large blast, it is only necessary to consider the numerical value of the ratio $\frac{E_2}{R_1}$ for a single cell, the cost per cell (K), and the relative convenience (economy) of manipulation (M); that is, the figures of merit for any type of battery is proportional to $\frac{E_2 M}{R_1 K}$.

For example, suppose one type of battery (A) to have an electro-motive force of 2.0 volts, an internal resistance of 0.2 ohms, a cost of ten dollars per cell, and a relative economy of manipulation denoted by 5; and a second type (B) to have for these quantities respectively the values 1.0 volts, 0.5 ohms, one dollar and 3. Then, for relative merit:

$$\text{Type (A)}.....\frac{2_2 \times 5}{0.2 \times 10{,}00} = 10.$$

$$\text{Type (B)}.....\frac{1_2 \times 3}{0.5 \times 1.00} = 6.$$

That is, the more costly type would really be the more economical battery in the ratio of 10 to 6.

Another point likely to suggest itself is, how any given number of cells ought to be divided in separate circuits, and coupled in each circuit, to secure the best result. Although the statement may at first seem to be a little paradoxical, the matter is one simply of convenience. This is evident from a study of Eq. (2); for, when L is eliminated, as we have seen should always be done in practice, if we denote by x the number of cells coupled in series, and by y the number coupled in derived circuit, e and $r_1$ referring to a single cell:

$$N = \frac{1}{4 C_2 F} \times \frac{x_2 e_2}{\frac{x r_1}{y}} = \frac{1}{4 C_2 F} \times \frac{e_2}{r_1} \times x y$$

Hence no change in N can be caused by any variation in the arrangement of the cells, provided only that, as required by Eq. (3), $\frac{x e}{2 n F}$ be never made less than C. Indeed, a little reflection will show that this must be the case, since by the theory of the method the fuses are always so grouped as to develop the maximum energy attainable from the elements; and, of course, no mere change of arrangement can generate or destroy energy. In practice, then, the number of cells to be coupled in series would be determined by the number of fuses which could most conveniently be united in single groups; while the number of cells to be coupled for quantity would depend upon the desired number of groups in each circuit. From these conditions, in the case of very large blasts, the dividing of the battery into separate circuits to be closed simultaneously, naturally results. The general formulæ for these computations are the following, derived from Eq. (3) and Eq. (4):

$$x = \frac{2 F C}{e} n$$

$$y = \frac{\frac{N}{n} 2 C \times r_1}{x e - \frac{N}{n} 2 C L}$$

As has already been repeatedly stated, the quantity L should be made to disappear by a judicious selection and arrangement of the lead wires and connections. If this be neglected, great loss of power will be unavoidable, as is apparent from the latter of these equations. Indeed, the chief reason for recognising this quantity in framing Eq. (1), was to exhibit clearly the importance of making it zero.

In choosing the fuse, the quantities F and C are to be considered. The conditions to be fulfilled by the former are simple, since it is only necessary that it be as small as possible consistent with securing the minimum value for C; and this, aside from the choice of suitable local lead wires, is a matter only to be learned by judicious experiment. The quantity C calls for more careful study.

In the method I have devised for use at the School of Submarine Mining at Willet's Point, in determining the number of webers needful to explode a single low tension fuse of any particular type, the fuse and a standard Helmholtz-Gaugain galvanometer of low resistance are placed in the unknown side of a Kirchoff-Wheatstone bridge. The known side is a standard ohm. The battery consists of three small Grove cells in good condition, and contact is made by the sliding piece upon the platinum-iridium wire which forms the two variable sides of the bridge. For balancing, a Service Bradley galvanometer is employed, use being made of the coil having about an ohm resistance. In the main battery circuit is included a Wheatstone rheostat having a total resistance of about 40 ohms, by which the current can easily be regulated. Three operators are needful—one to gradually increase the current, by unwinding the wire from the wooden to the brass cylinder of the Wheatstone rheostat, until the fuse explodes; one to keep the bridge balanced by moving the solid contact piece on the wire, as the resistance of the fuse increases under the heating effect of the current; and one to read the Helmholtz-Gaugain galvanometer, which, since the Weber co-efficient has been accurately determined, makes known the current traversing the fuse at any instant.

By this method the resistance of the fuse when cold, and at any subsequent temperature, may be noted exactly; while the corresponding current is accurately measured up to the instant of explosion.

In this manner the constants of many different types of fuses have been experimentally determined.

The following table exhibits the data for four of them, which will be designated as A, B, C and D. Type A consists of $\frac{1}{18}$ inches of platinum wire 0.0025 inches in diameter; type B of $\frac{1}{18}$ inches of platinum silver wire 0.0015 inches in diameter; type C of $\frac{1}{18}$ inches of gold iron wire 0.0020 inches in diameter; and type D of $\frac{1}{18}$ inches of platinum silver wire 0.0015 inches in diameter—all charged with a priming of fulminating mercury.

CONSTANTS OF SINGLE FUSES.

| Types. | Resistance in ohms. | | | Current in webers to effect explosion. |
|---|---|---|---|---|
| | Cold. | At explosion. | Diff. | |
| A. | 0.72 | 0.82 | 0.10 | 0.45 |
| B. | 1.49 | 1.57 | 0.08 | 0.33 |
| C. | 1.87 | 1.96 | 0.09 | 0.34 |
| D. | 1.90 | 2.01 | 0.11 | 0.28 |

The method of measurement just described gives accurately the current required to effect the explosion of a single fuse—but it is needful to observe that *time* enters as an element. For a single fuse this is not important, since the interval is exceedingly small; but when fuses connected in series are employed, it cannot be ignored. Experience shows that in this case, unless an excess of current be used, the most sensitive fuse explodes first, and by breaking the circuit saves its neighbours.

(*To be continued.*)

## ANSWERS TO QUERIES.

ENOCH ARDEN, *Queensland.*

1. There is no line of any length or consequence in England upon which the Wheatstone apparatus is not used. There are 64 of them in use at the Central Station alone.

2. They are in incessant use for all purposes, and convey probably three-fourths of the work done by the Post-Office.

3. The instrument is only a modification of the Morse, and is as certain to supersede the old form of apparatus as a race-horse has superseded a donkey in running for the Derby. Where speed, accuracy, and economy are needed, the automatic system is a necessity of the age.

4. The St. Petersburg Convention does not regard the form of keys in use, and the Wheatstone Automatic is only another species of key.

5. 600 miles—but this is because there is no other longer.

6. The ordinary wires are used. Induction is embarassing only when two wires run for a long distance side by side. In England this is avoided as much as possible.

7. Circuits are worked with the Morse instrument independent of their length, and only when the work is light. As the work increases, the automatic system is introduced, and by this means the capacity of the wires is doubled and trebled according to distance.

8. Wheatstone's instruments are obtainable from the British Telegraph Manufactory, Euston-road, London.

M. A.

[For further information you had better apply to the executors of the late Sir Charles Wheatstone, in whose hands, we believe, the patents of Automatic system are at present. If your application is made on behalf of telegraph administration, we have no doubt they will supply you with all the information you desire as to price, &c. Their address is Grosmont House, Hampton Wick. For an account of the Hicks and Milliken repeaters, see Davis and Rae's "Handbook of Electrical Diagrams and Connections" (Haughton and Co., London).—ED. *T. J.*]

A. *Z.*—The Telephone was invented by Reuss in 1861. M. La Cour's first experiment was successfully made on 5th June, 1874. A distinction should be made between *telephony* and *phono-telegraphy*.

B.

## QUERY.

The Committee on Postal Telegraphs thought it desirable to have a class of "Instructors." Is there any likelihood of such an appointment being created, and what is its probable status?

E. T. G.

## PATENTS.

4270. J. C. and G. FULLER.—"Improvements in galvanic elements."—9th December.

4278. S. ROBERTS.—"Improvements in apparatus for manufacture of cast flanged pipes, columns, telegraph posts, lamp pillars, and other cast hollow and solid flanged articles."—9th December.

4289. J. SERPAUX.—"An improved electric pile."—10th December.

4302. R. J. BLEWITT.—"An improved method of coating iron and other metal with tin."—11th December.

4311. A. M. CLARK.—"Improvements in dynamo and magneto-electric machines."—11th December. (A communication.)

4326. J. H. ELLERBECK.—"Improvements in the production of motive-power and in apparatus therefor."—14th December.

4342. E. P. ALEXANDER.—"Improvements in gas motive-power engines and in the means for regulating and transmitting their motion."—15th December. (A communication.)

4384. W. SMITH.—"Improvements in joining telegraph-wires."—17th December.

4392. M. PRENTICE.—"Improvements in the construction of platinum vessels exposed to heat or strain."—18th December.

4426. A. M. CLARK.—"Improvements in and connected with autographic or copying telegraphs." (A communication.)

4482. M. BENSON.—"Improvements in telegraph apparatus."—24th December. (A communication.)

4515. H. WILDE.—"Improvements in the manufacture of metal-rollers for printing calico and other textile fabrics, part of which is applicable to the refining of copper."—28th December. (A communication.)